Army Research Laboratory

Development and Evaluation of a Surface-Mount, High-G Accelerometer

by Philip J. Peregino II and Edward Bukowski

ARL-TR-3331 September 2004

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14. ABSTRACT
The Endevco model 7270A high-g accelerometer has been used successfully in numerous flight tests at the U.S. Army Research Laboratory. The accelerometer is available in ranges as low as 6,000 g’s and up to 200,000 g’s, so they can be used in a variety of situations to measure setback, setforward, and balloting in artillery rounds, mortars, and tank projectiles, to name a few. However, one of the disadvantages of the model 7270A is its physical size. In the area of die level and surface mount components, the 7270A is relatively large. The sensing element is packaged inside a metal case with screw holes for mounting to a rigid surface. In addition, there are wires protruding from the case for electrical connections. In the area of munitions, small cavities don’t always afford the room for a large gage. It was desirable to repackage the die in a smaller container and make it a surface mount component for a printed circuit board. A contract was awarded to Endevco to repackage the existing die and to develop a triaxial version using that repackaged die. The newly developed accelerometers were tested and evaluated at the U.S. Army Research Laboratory.

15. SUBJECT TERMS
accelerometer, high-g, Endevco, surface mount

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In addition, Barry Bolton and Ken McMullen from the U.S. Army Aberdeen Test Center provided necessary assistance with the design of the accelerometer test boards.

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1. Introduction

The Endevco model 7270A high-g accelerometer has been used successfully in numerous flight tests at the U.S. Army Research Laboratory (ARL). The accelerometer is available in ranges as low as 6,000 g's and as high as 200,000 g's, so they can be used in a variety of situations to measure setback, setforward, and balloting in artillery rounds, mortars, and tank projectiles, to name a few. However, one of the disadvantages of the model 7270A is its physical size. In the area of die level and surface mount components, the 7270A is relatively large. The sensing element is packaged inside a metal case with two clearance holes for no. 2 screws to mount the gage to a rugged surface. From this metal case, wires protrude to make the electrical connections. A photo of the gage can be seen in figure 1.

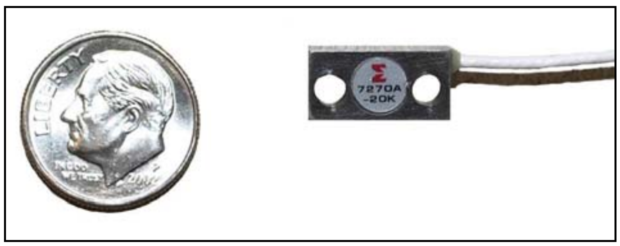

Figure 1. Endevco model 7270A accelerometer.

With the small cavities available in the area of munitions, a gage of this size will often consume a lot of valuable real estate and in some situations will not fit at all. The intent was to repackage the gage in a surface mount component that could be mounted directly to a printed circuit board (PCB). It was desirable to use the existing die, or one with similar electrical characteristics, and replace the metal housing and mounting scheme with a much smaller package that would consume considerably less space. Endevco was contacted and it was determined that repackaging the die in a smaller surface mount package was an achievable effort. Through the Hardened Subminiature Telemetry and Sensor System program, a contract was awarded to Endevco for this effort, with testing and evaluation at ARL.

2. Single Axis Accelerometer

The die from the existing 7270A accelerometer was repackaged in a small plastic carrier and a surface mount, high-g accelerometer, the model 70, was developed by Endevco. The 7270A is ~0.565 × 0.275 × 0.110 in, whereas the model 70 accelerometer is ~0.250 × 0.125 × 0.075 in. Since the model 70 is a surface mount component, there are no wires extending from it. A photo of the two gages side by side is shown in figure 2. The model 70 gage was made in three different g's levels: 6,000, 20,000 and 60,000 g's. The specifications of the model 70 gage are listed in appendix A.

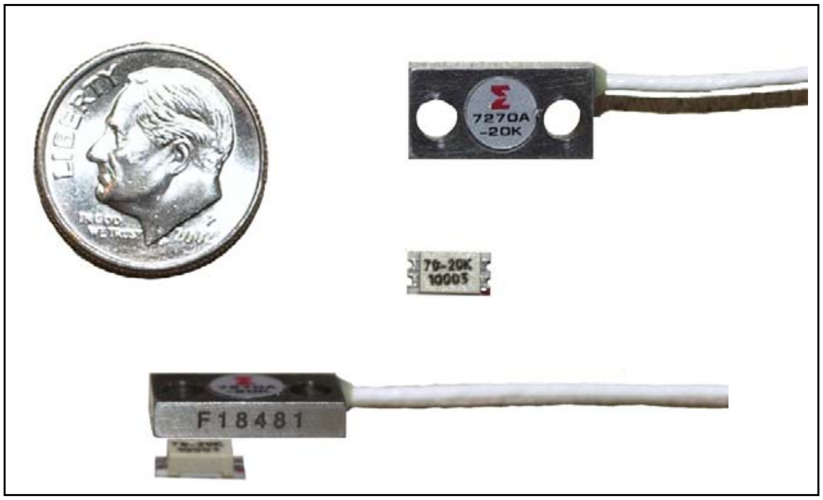

Figure 2. Model 70 accelerometer vs. 7270A.

Endevco, independent of this contract, was redesigning the die used in the 7270A gages. Leveraging that effort, the die used in the model 70, 60,000 g's accelerometer is the new design, whereas, the 6,000-g's and 20,000-g's gages use the existing die. The new die was designed to be transparent to the user in that it had the same or similar electrical and mechanical properties. The main differences are that it is easier and less time consuming to assemble. The existing design requires eight wire bonds, four on the top and four on the bottom, whereas, assembly of the new die requires only four wire bonds and all of them on top.[1]

3. Single Axis Accelerometer Shock Tests

Shock table tests were performed on the gages to determine if they performed according to the specifications in the contract. An MTS shock table at ARL was used to perform the tests. The shock table is capable of imparting from a very small shock with a relatively long duration up to a shock as high as 30,000 g's with a short (microsecond) duration. As the shock load increases, the maximum duration obtainable decreases.

To operate the shock table, the device tested is rigidly mounted on a table and, as a unit, the table and device are raised to a given height and held in place via a set of brakes. A bungee cord, attached to the table, applies force in the direction of the base. The higher the table is raised, the more the bungee cord stretches and the load is increased. To impart the shock, the brakes are

[1]Sill, B. Endevco, San Juan Capistrano, CA. Private communication, 2002.

released and the table slams down on a solid base. A buffer material, such as felt, is placed on the solid base to program the level of shock. The duration and level of shock is determined by the height of the table and the thickness and makeup of the buffer material. To increase the shock duration, a thicker and/or softer buffer material is used; however, this reduces the maximum shock load for a given height. To obtain a given shock load with a thicker material the table height has to be increased. The trade-off between shock duration and shock pulse is controlled by the table height and buffer material. Figure 3 is a photo of the shock table.

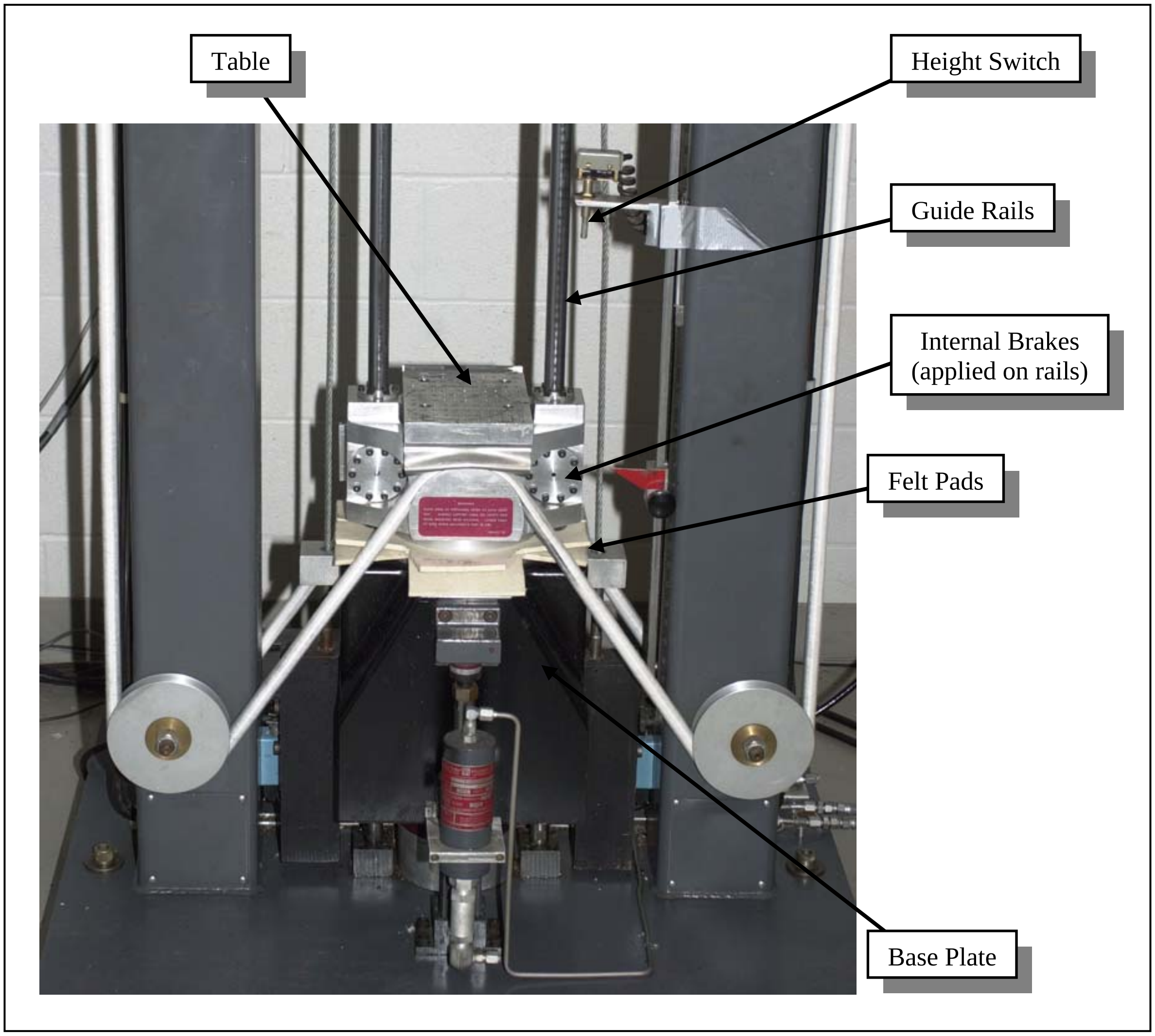

Figure 3. MTS shock table.

Due to several variables on the shock table, it does not always give an identical shock. In order to compare the 7270A gage and the model 70 gage, it was desirable to test them at the same time on the shock table and observe the response of each one. A circuit board was designed and developed that would provide the power regulation for both gages. Figure 4 shows the circuit board with both the 7270A and the model 70 gage mounted on the board. Note that one side of the 7270A gage was cutoff in order to make it fit on the circuit board. This procedure is used frequently to fit the gage in small locations. Instead of securely mounting it with screws, it was glued to the board with 5-min epoxy and the entire board was bolted to an aluminum plate later mounted to the shock table. With this setup, the two gages are as close together as possible, allowing for a good comparison on the shock table. Figure 5 shows the accelerometers and fixture mounted to the shock table.

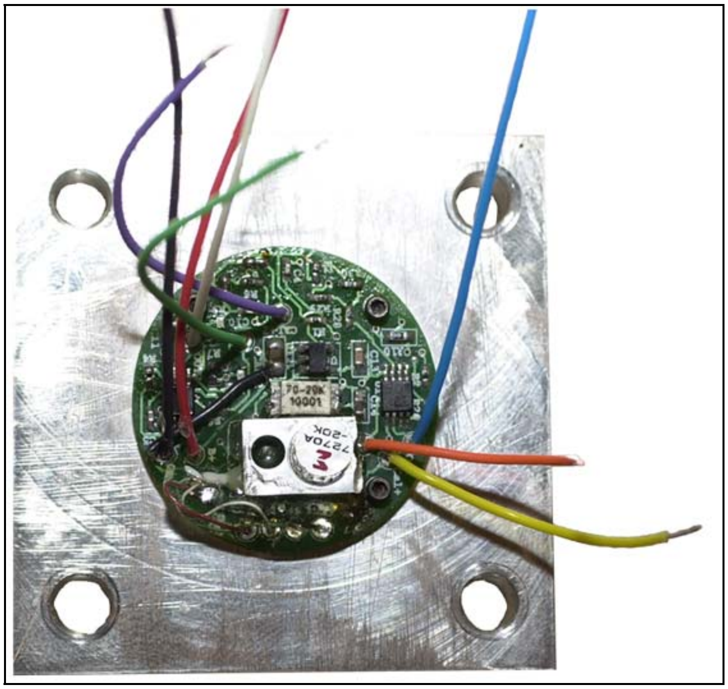

Figure 4. Accelerometers on PCB and test fixture.

Tests were performed with the gages mounted on the shock table, as shown in figures 4 and 5. The sensor output was measured and converted to acceleration according to the gage factors supplied by Endevco with the gages. Figures 6 and 7 are plots of two tests of the model 70 gage vs. the 7270A gage. The graphs show that the response of the model 70 gage is very similar to the response of the 7270A gage. There are minor variations in the shock pulse from one gage to the other; however, this can be expected. Even though the gages were mounted as close together as possible, there are still variations that can occur on the shock table and it is possible that the PCB could have some minor deflections contributing to variations in the shock pulse measured.

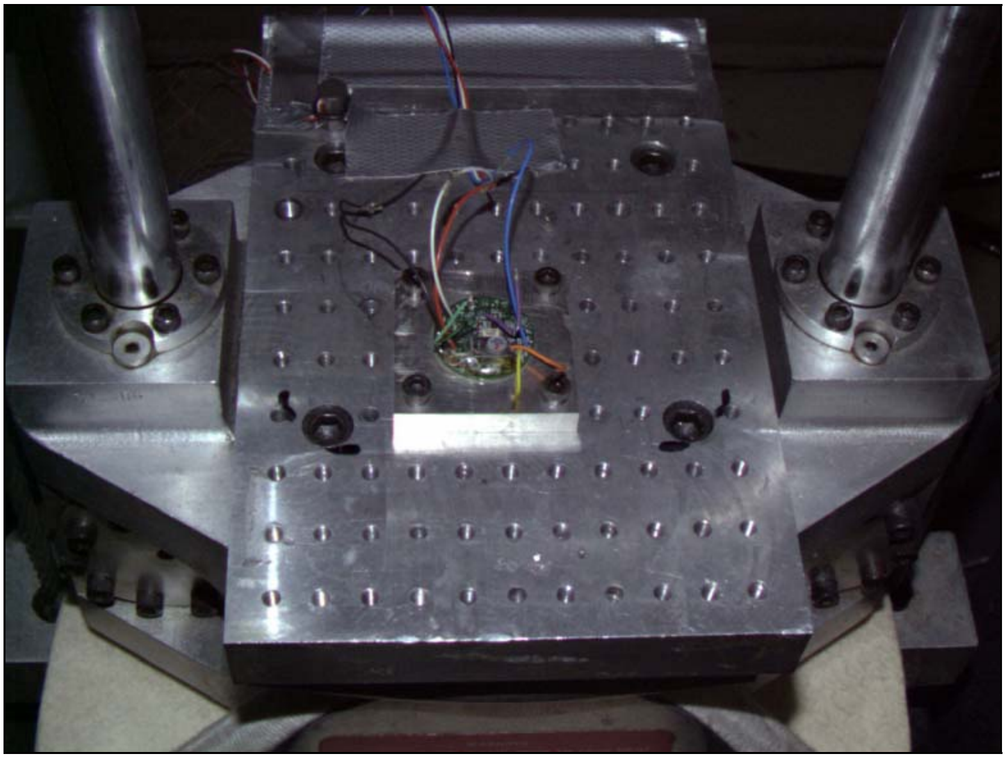

Figure 5. Accelerometers mounted to shock table.

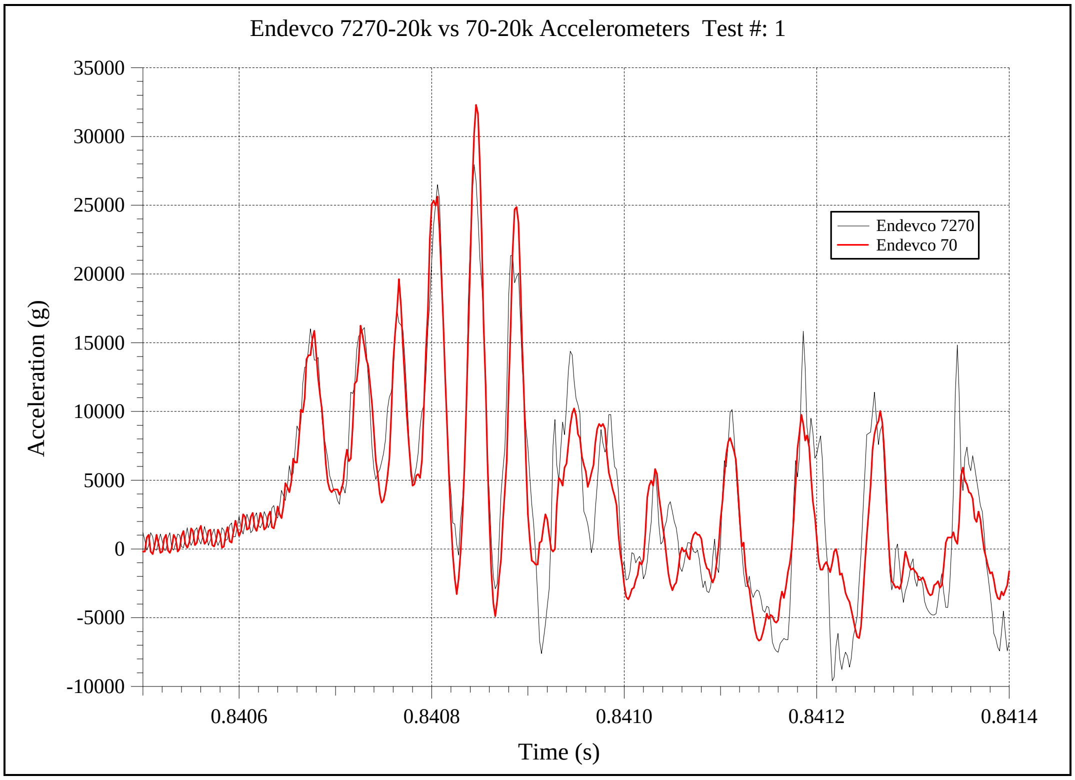

Figure 6. Shock pulse from test 1 of the model 70 accelerometer.

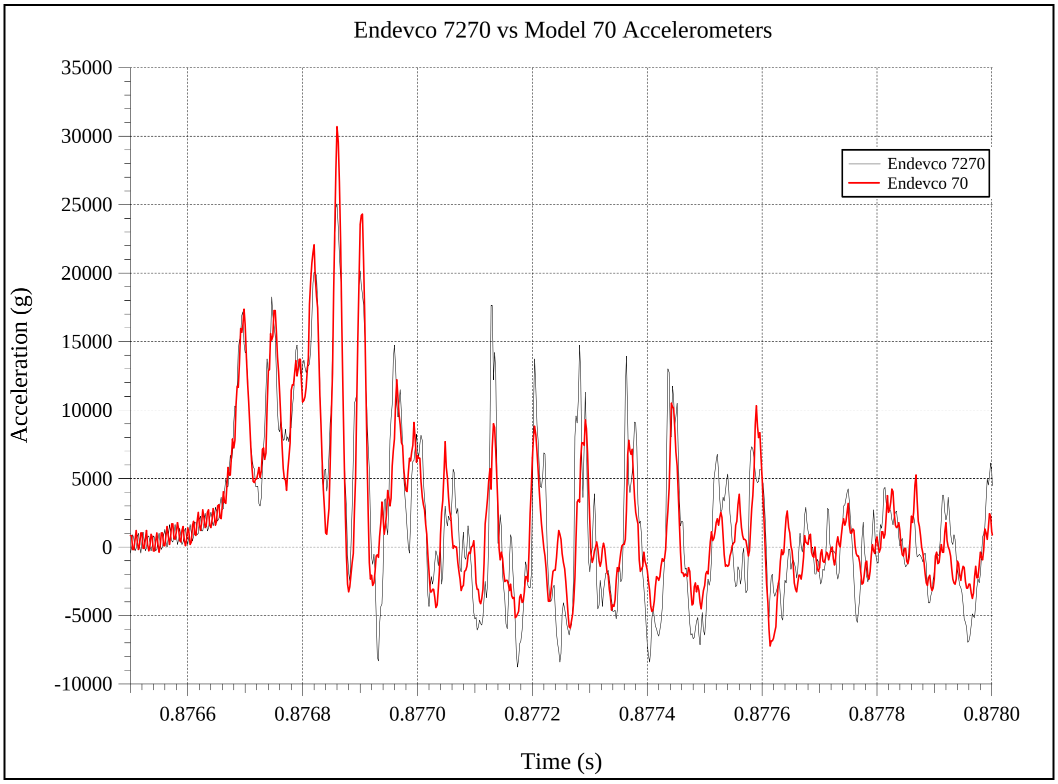

Figure 7. Shock pulse from test 2 of the model 70 accelerometer.

4. Triaxial Accelerometer

In addition to repackaging the die, it was also determined that it would be beneficial to have a surface mount, high-g, triaxial accelerometer. The second phase of the contract was to mount three model 70 gages on a cube that would allow for the measurement of acceleration in all three axes. A cube was developed with electrical traces and three accelerometers were mounted on it. On the bottom of the cube were solder pads so conductive epoxy could be used to mount it to a PCB. In addition to the pads on the bottom of the board, there were also pads on top for wire, in case these were the desired connection points. The accelerometer on the top of the cube was a 60,000-g's accelerometer and the two on the sides were 6,000-g's gages. Any of the three ranges (6, 20, or 60k) can be mounted on the cube; however, the configuration was chosen for a typical gun launch where the top gage would measure setback acceleration and the side gages would measure balloting. Figure 8 is a photo of the model 73 triaxial accelerometer block.[2] The specifications for the model 73 gage are in appendix B.

[2]Connolly, T.; Casucci, P. Photo from a presentation entitled Miniature Tri-axial Silicon Accelerometer. *HSTSS Symposium,* Orlando, FL, 14 August 2003.

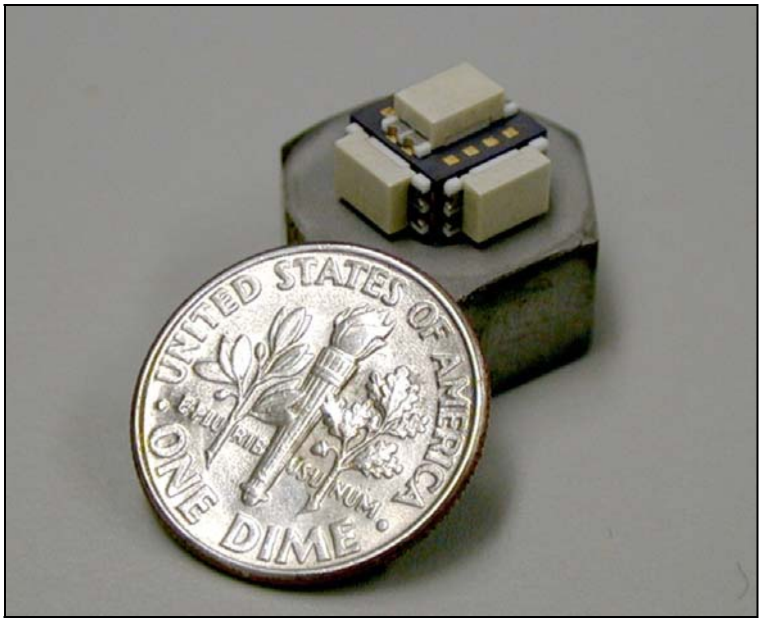

Figure 8. Model 73 triaxial accelerometer.

5. Triaxial Accelerometer Shock Tests

A PCB was developed to test the triaxial accelerometer on the shock table. The PCB provided the power for all three of the accelerometers on the cube. The accelerometer was attached to the PCB via conductive epoxy on the pads on the bottom of the cube. Figure 9 shows the triaxial accelerometer mounted to the PCB.

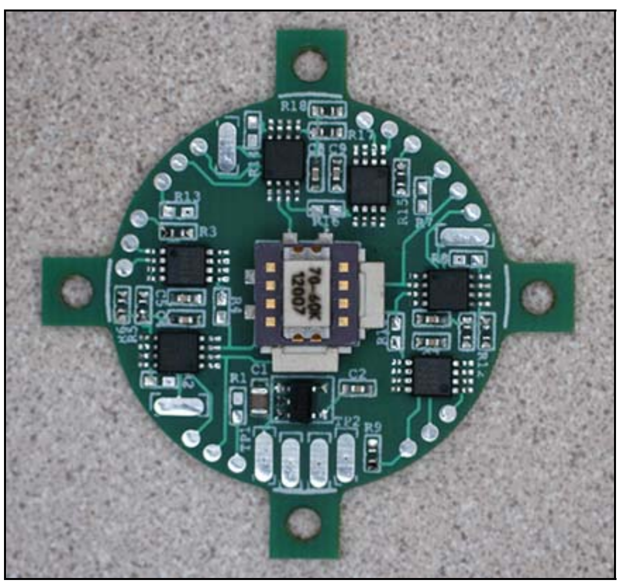

Figure 9. Triaxial accelerometer and PCB.

Similar to phase 1, a 7270 was mounted near the accelerometers as a reference; however, due to space limitations, it was not mounted on the PCB. The 7270A was mounted next to the PCB as shown in figure 10.

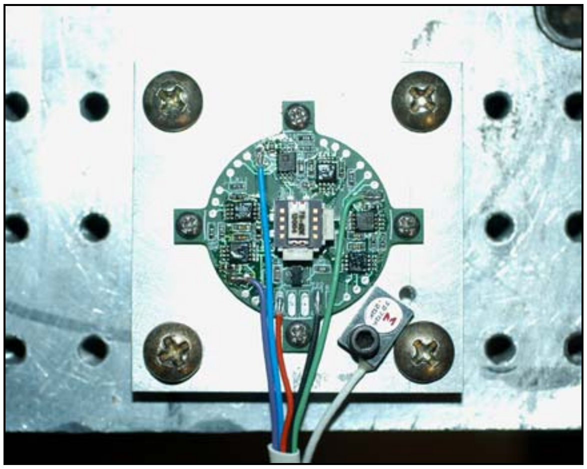

Figure 10. Triaxial accelerometer and reference accelerometer.

The accelerometers were tested in the configuration shown and the results of the first test are shown in figures 11 and 12. The z-axis is the axis in the direction of movement of the shock table, whereas the x and y axes are perpendicular to the axis of movement. The response from the z-axis gage on the model 73 gage is very similar to the 7270A accelerometer. The x and y axis gages measured a small amount of acceleration, which is expected because the shock table is a very harsh environment and it does not produce a unidirectional shock. Although not planned, there is lateral movement which is measured by the x and y accelerometers.

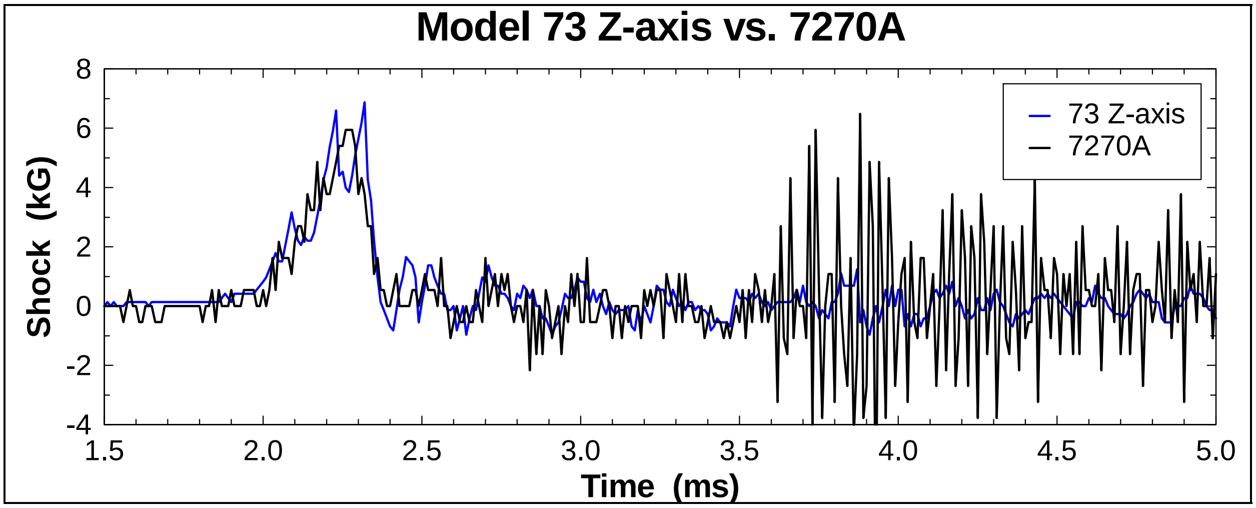

Figure 11. Test 1 of the triaxial accelerometer (z axis).

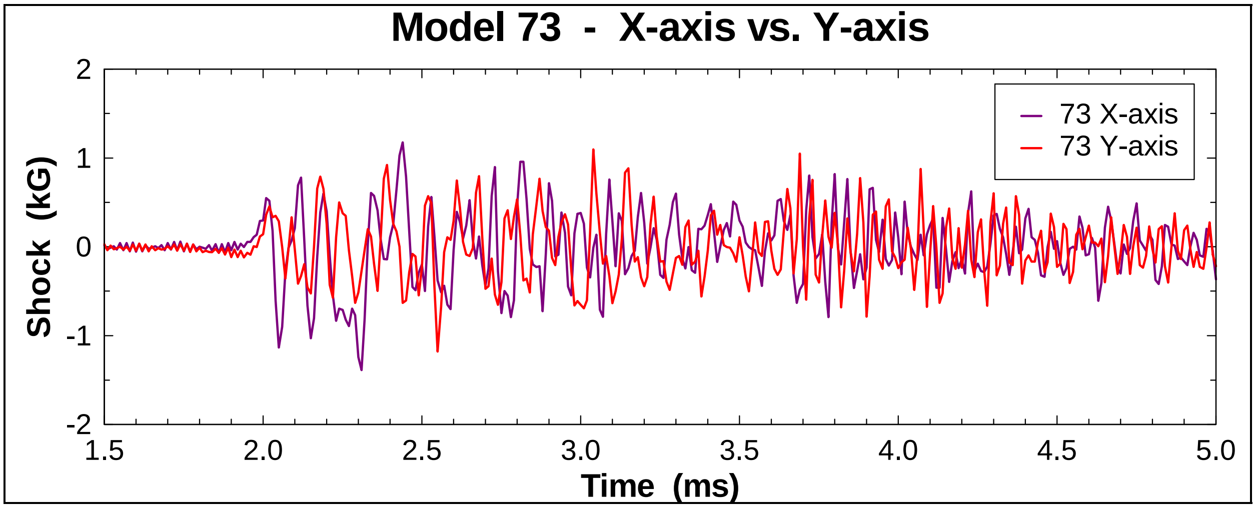

Figure 12. Test 1 of the triaxial accelerometer (x and y axis).

The shock level was increased to determine how well the gage handled a high shock load. Figures 13 and 14 show the results of the test with a shock load of 10,000 g's. In this test, the z axis and y axis gages failed midway. After careful inspection, it was determined that the failure was caused by the gage separating from the board; the conductive epoxy was not strong enough to hold the cube.

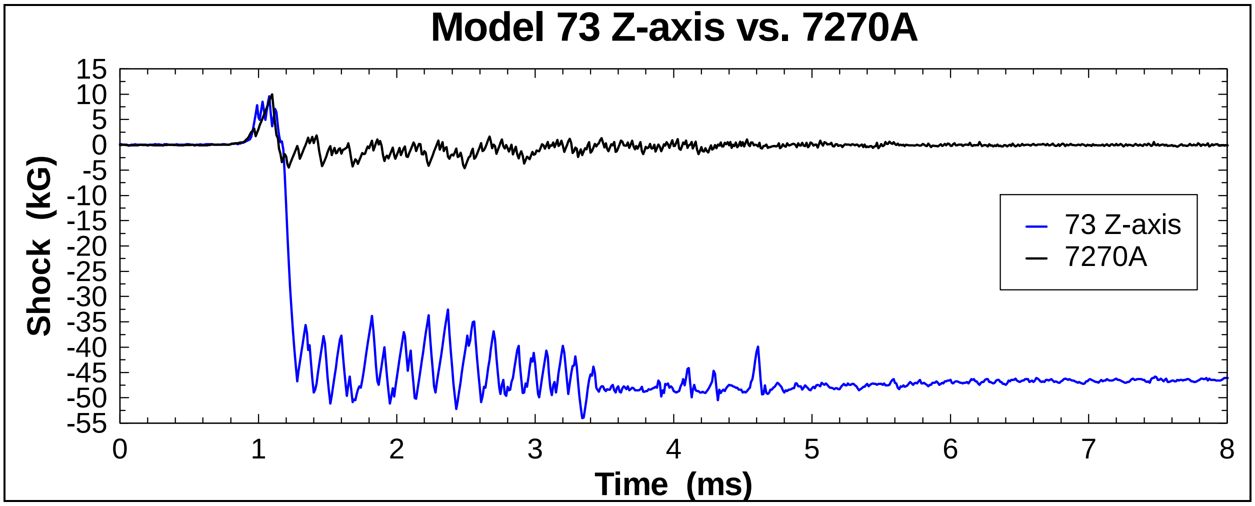

Figure 13. Test 2 of the triaxial accelerometer (z axis).

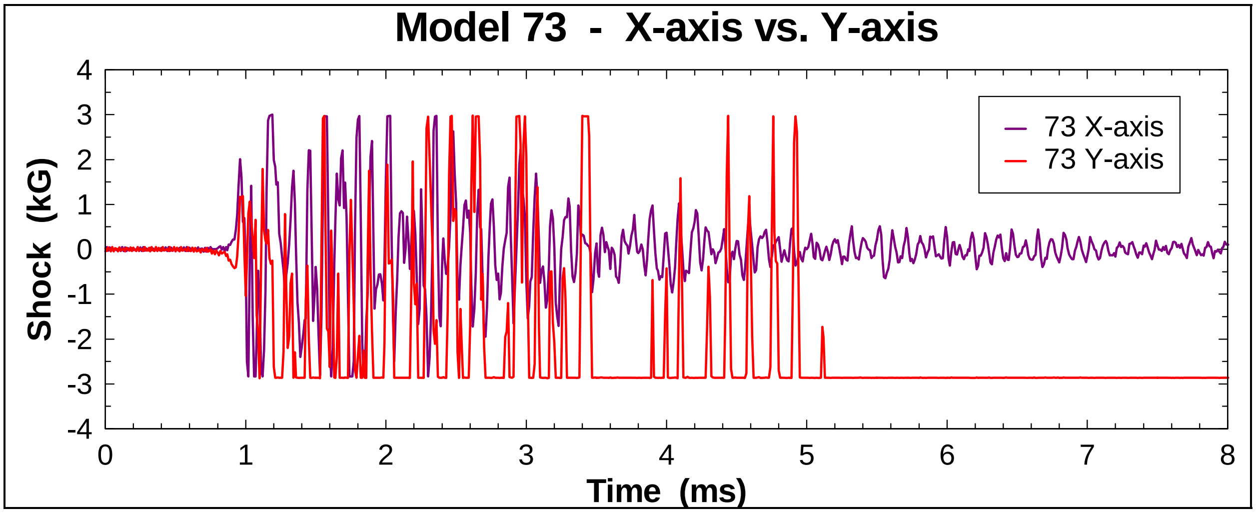

Figure 14. Test 2 of the triaxial accelerometer (x and y axis).

A second set of tests was performed with another accelerometer to determine if it was possible to securely mount the accelerometer to the PCB. For this series of tests, Stycast epoxy was placed around the edges of the cube in addition to the conductive epoxy on the bottom of the cube. Figure 15 shows the mounting scheme for this series.

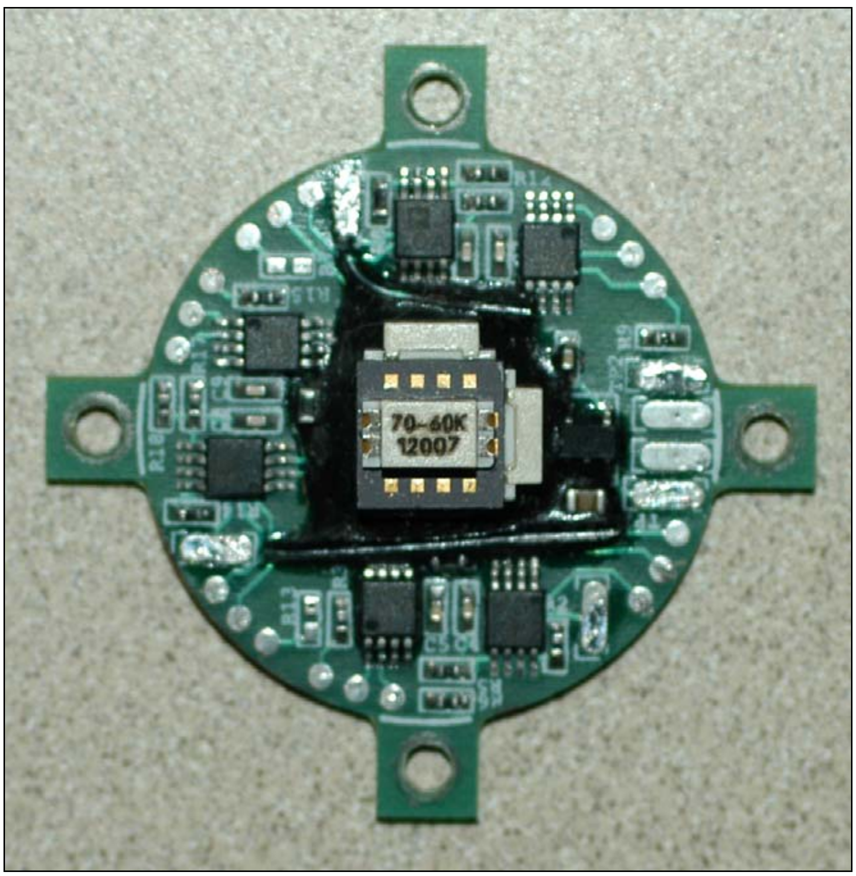

Figure 15. Accelerometer secured with Stycast epoxy.

The test series was repeated with the new mounting scheme and was shocked six times at increasing g' levels. The levels tested were ~5000 g's, 10,000 g's, twice at 20,000 g's, and twice at 30,000 g's. All six tests were successful. The shock pulses can be seen in figures 16–27.

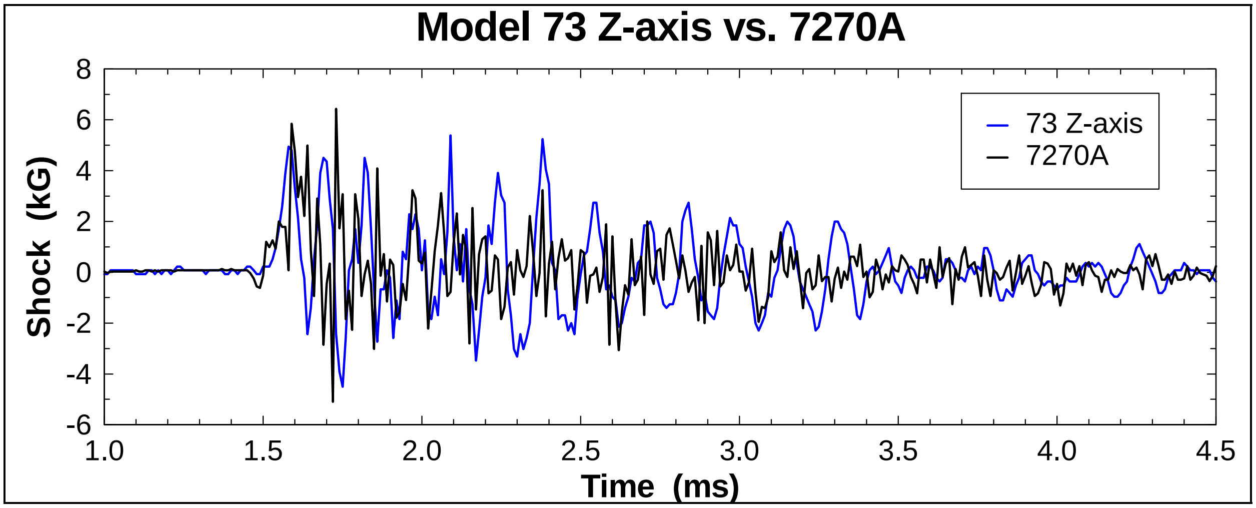

Figure 16. Test 1 of the triaxial accelerometer and Stycast epoxy (z axis).

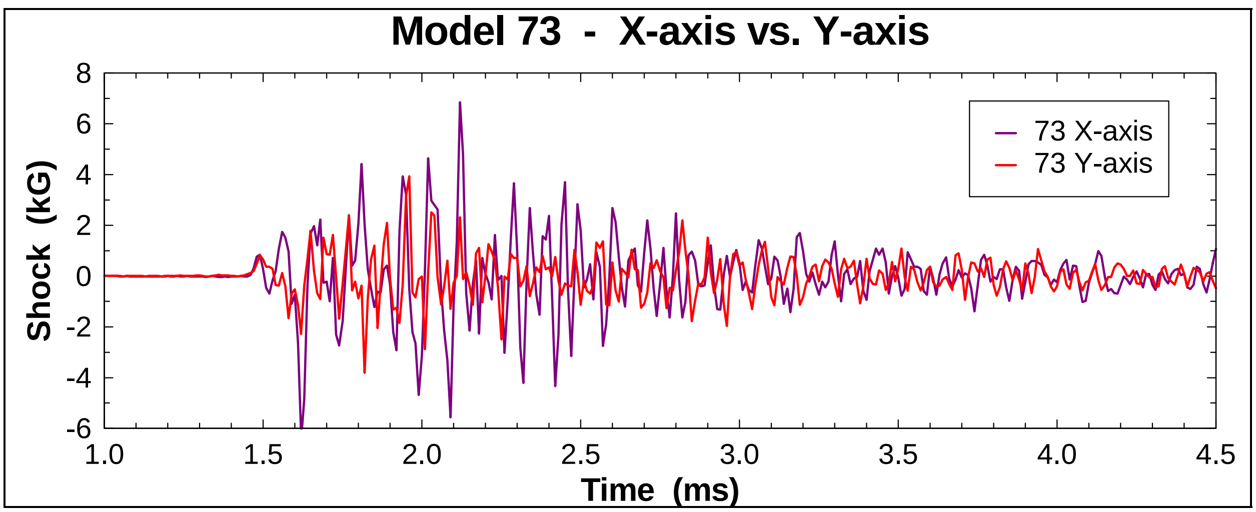

Figure 17. Test 1 of the triaxial accelerometer and Stycast epoxy (x and y axis).

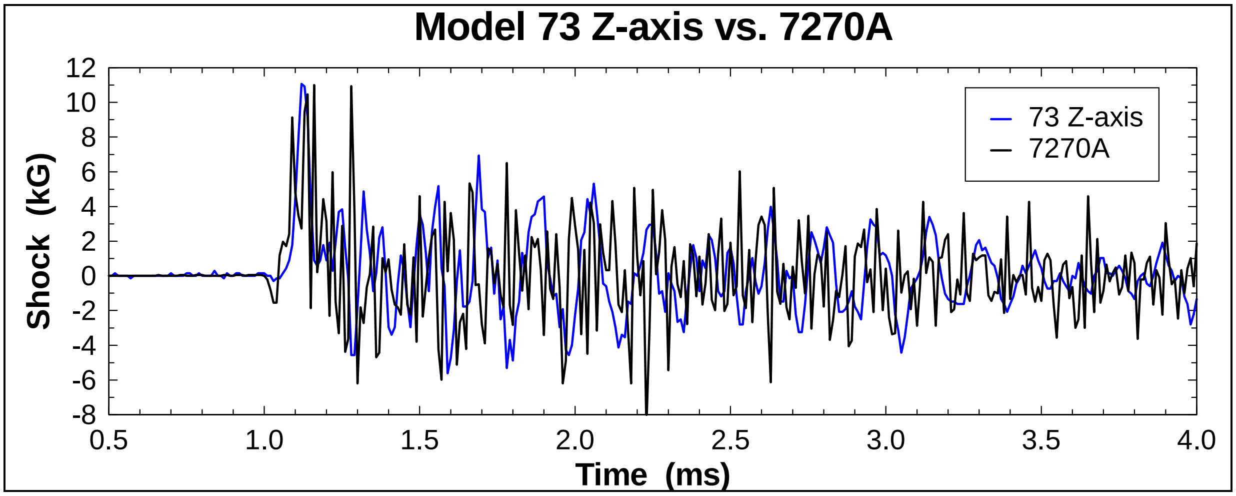

Figure 18. Test 2 of the triaxial accelerometer and Stycast epoxy (z axis).

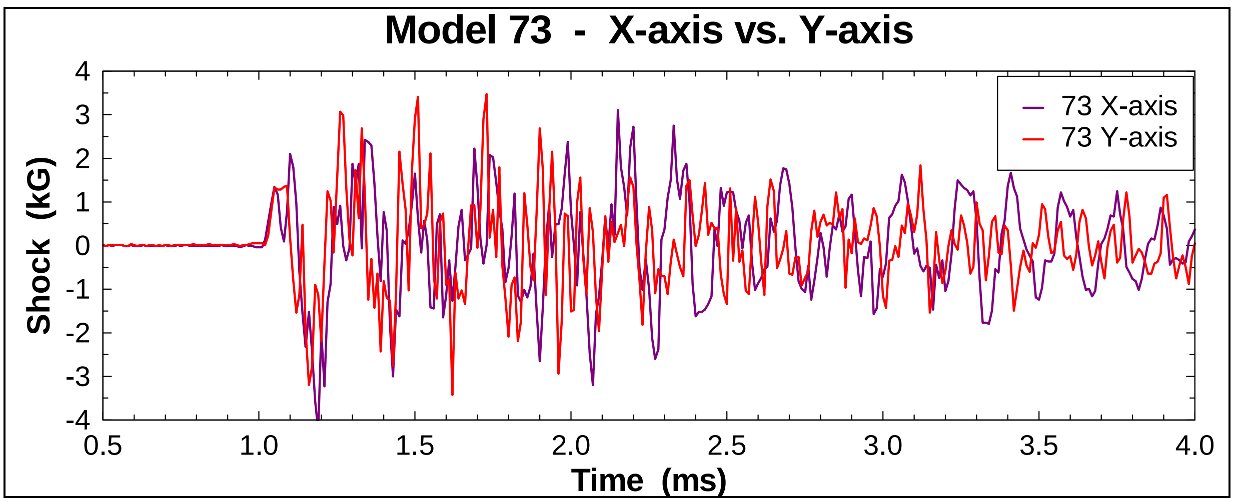

Figure 19. Test 2 of the triaxial accelerometer and Stycast epoxy (x and y axis).

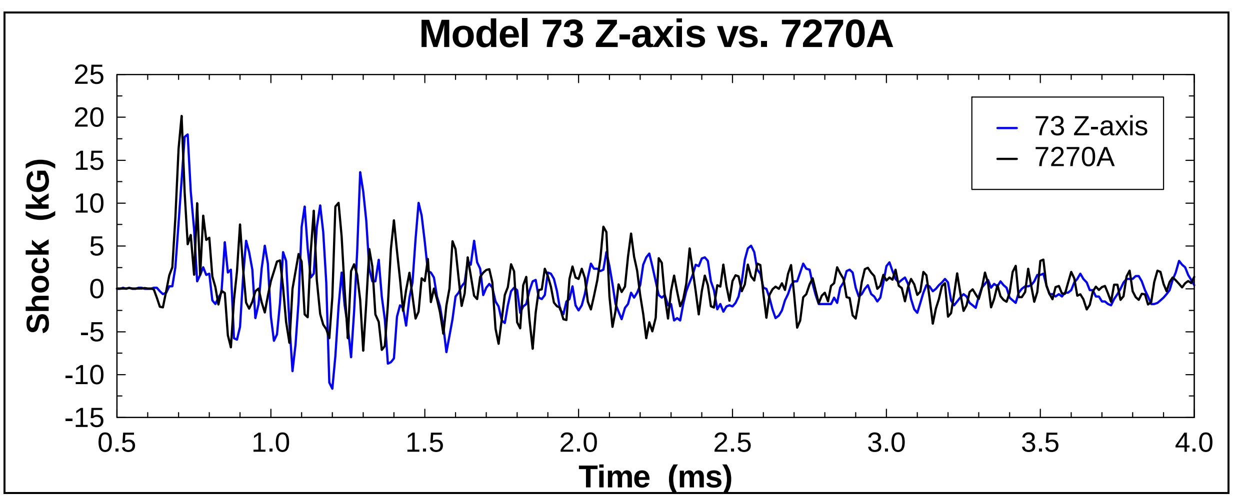

Figure 20. Test 3 of the triaxial accelerometer and Stycast epoxy (z axis).

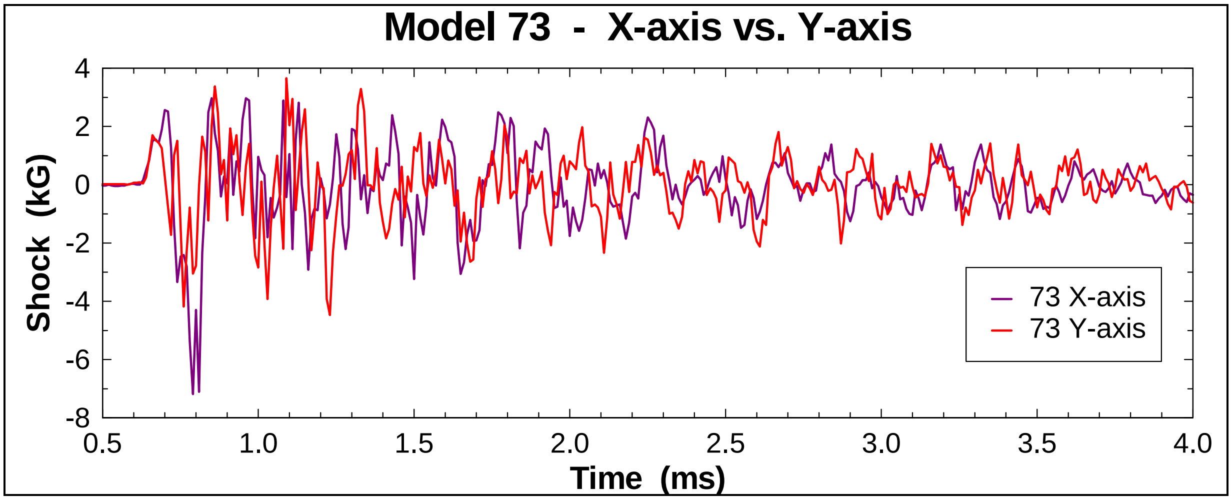

Figure 21. Test 3 of the triaxial accelerometer and Stycast epoxy (x and y axis).

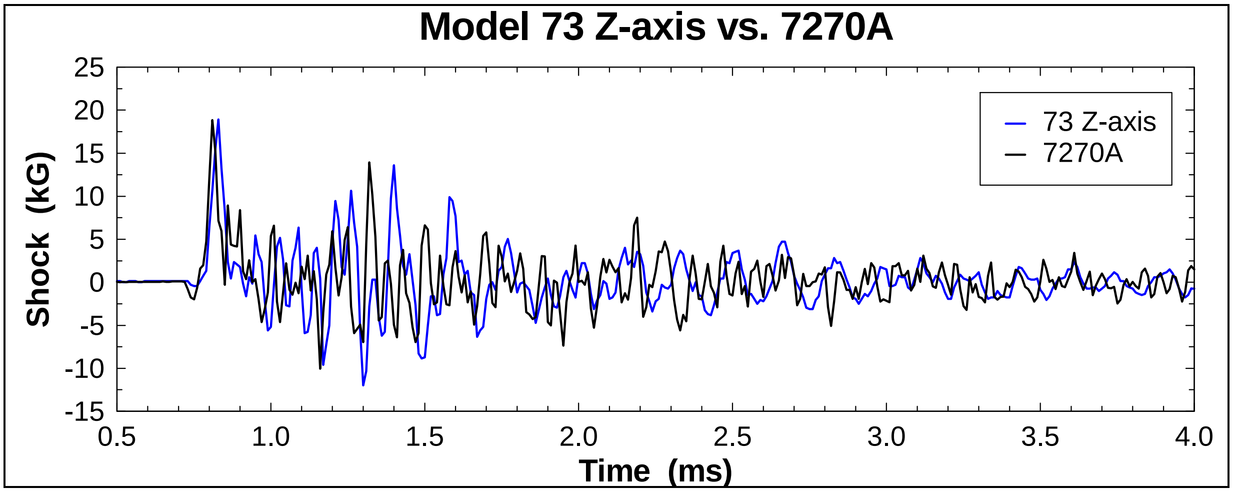

Figure 22. Test 4 of the triaxial accelerometer and Stycast epoxy (z axis).

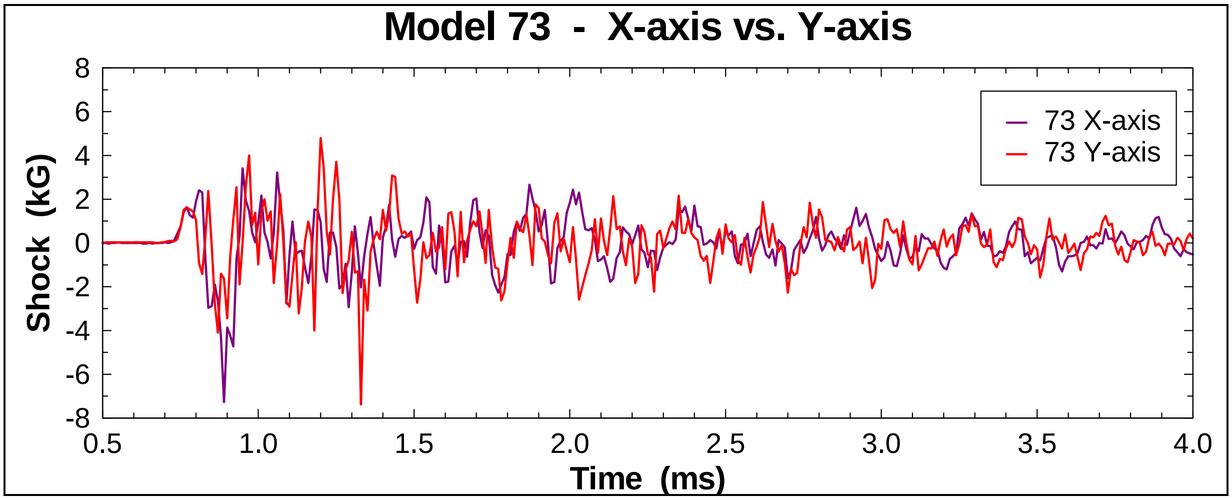

Figure 23. Test 4 of the triaxial accelerometer and Stycast epoxy (x and y axis).

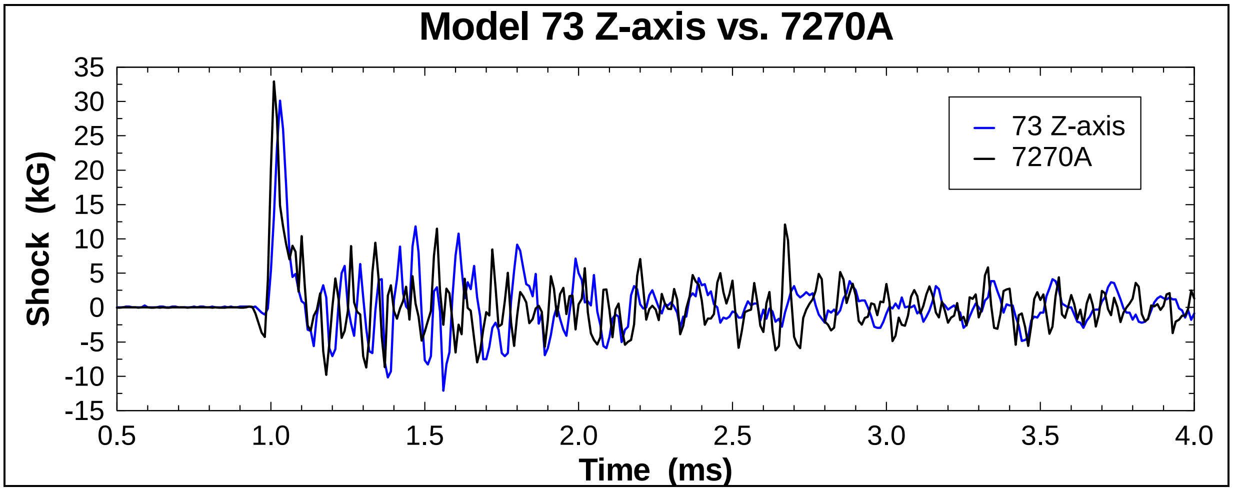

Figure 24. Test 5 of the triaxial accelerometer and Stycast epoxy (z axis).

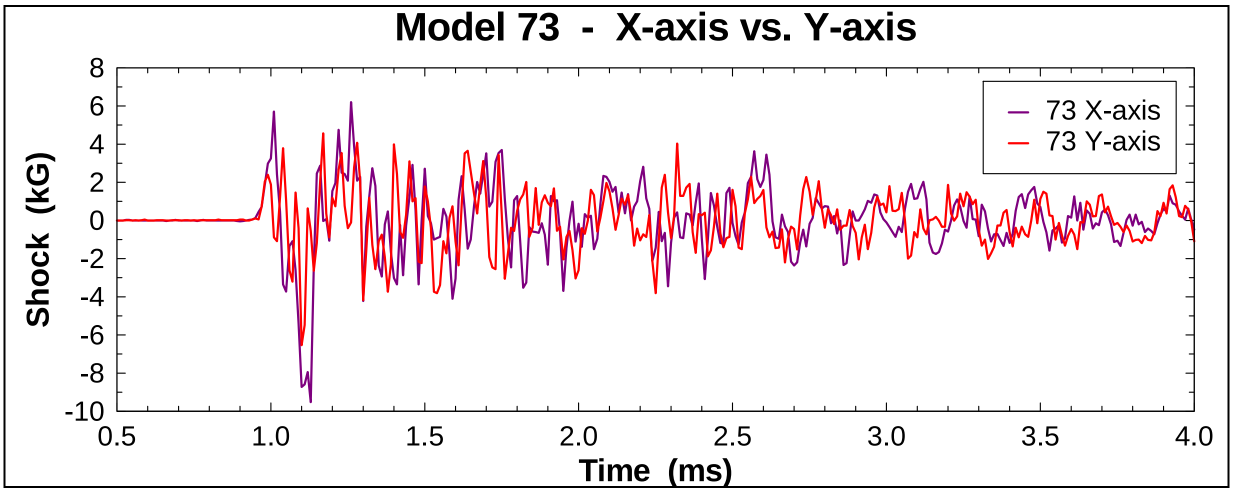

Figure 25. Test 5 of the triaxial accelerometer and Stycast epoxy (x and y axis).

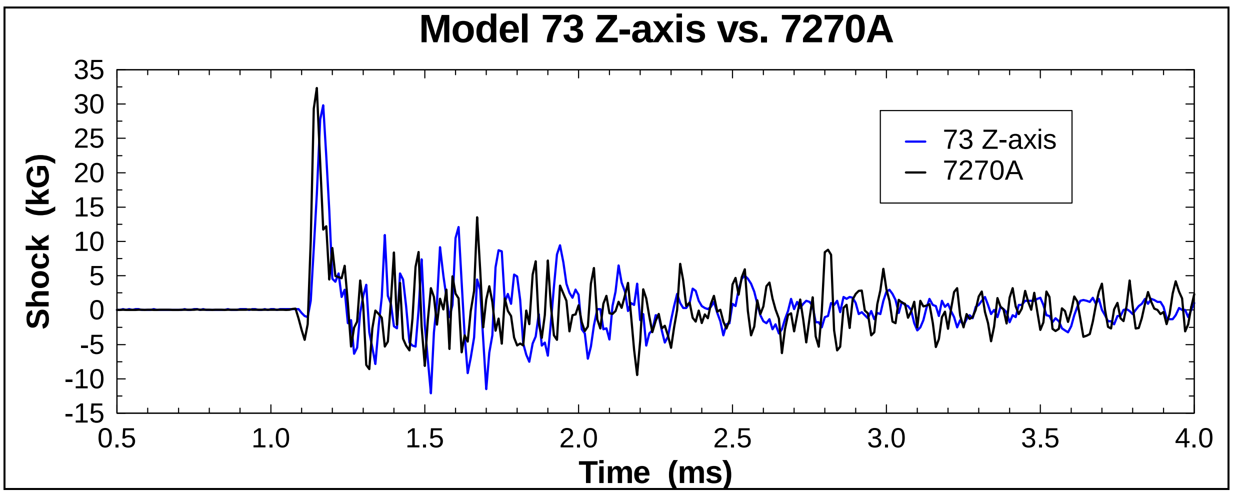

Figure 26. Test 6 of the triaxial accelerometer and Stycast epoxy (z axis).

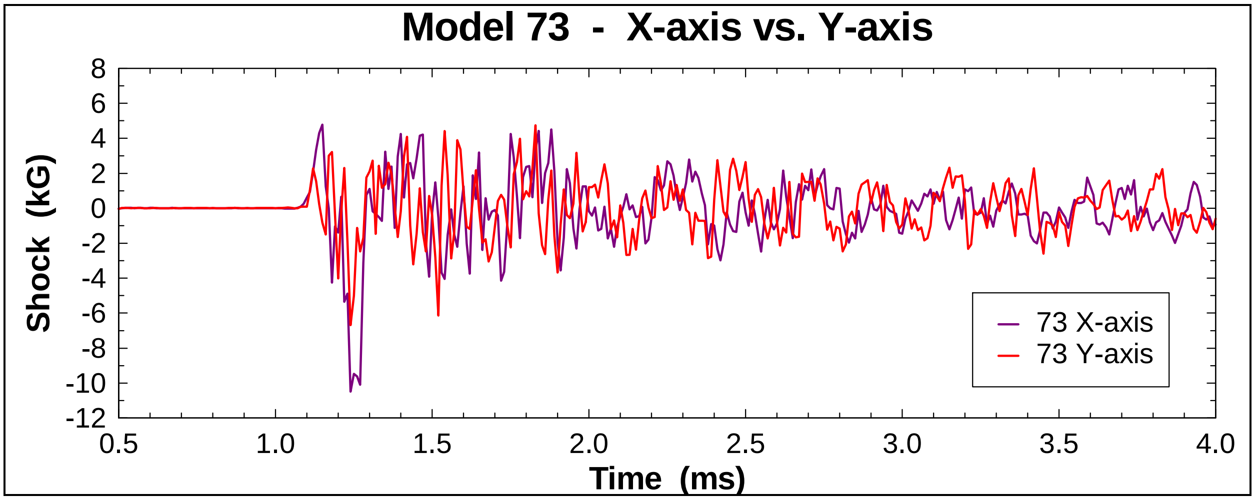

Figure 27. Test 6 of the triaxial accelerometer and Stycast epoxy (x and y axis).

6. Conclusion

Through a contract with Endevco, a new accelerometer, the model 70, was developed, which significantly reduced the size of the 7270A high-g accelerometer. The die of the 7270A was repackaged into a surface mount container that can be attached directly to a PCB; therefore, no protruding wires. The accelerometer was shock tested beyond 25,000 g's and the response was very similar to the standard 7270A gage. This new accelerometer frees up valuable real estate in the small cavities where instrumentation and sensors are often placed.

In addition, the model 70 gage was packaged on a small cube with wire traces to form a triaxial accelerometer, the model 73. The model 73 accelerometer can be connected to a PCB via conductive epoxy on the bottom of the cube or via pads on top of the cube for electrical connections. Shock tests were performed and it was determined that the conductive epoxy was not strong enough to hold the cube in place, so an additional epoxy, Stycast, was required to secure it in place. When properly secured, the accelerometer was shock tested numerous times up to 30,000 g's, and the response of the accelerometer in the z direction was very similar to the reference accelerometer.

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Appendix A. Model 70 Gage Specifications

This appendix appears in its original form, without editorial change.

ORIGINATED	RDS	01-16-03	PERFORMANCE SPECIFICATION ACCELEROMETER (FOR MODEL 70-XXX)	PS70	
CHECKED	JRL	01-16-03		PAGE	2 OF 5
APPROVED	RDS	01-17-03		REVISION	B
	LM	01-16-03		EO NUMBER	25728
				DATE	4-21-03

1.0 **DESCRIPTION**

The ENDEVCO® Model 70 is a family of miniature, rugged, undamped, piezoresistive accelerometers designed for shock measurements. The Leadless Chip Carrier package is designed for surface mount attachment to circuit boards. The highly efficient sensing system of the Model 70 is sculpted from single crystal silicon, which includes the inertial mass and strain gages arranged in a four-active-arm Wheatstone bridge circuit (patent numbers 4,498,229, 4,605,919 and 4,689,600). The extremely small size and unique construction of the element allows exceptionally high resonant frequency. On-chip balance resistors provide low zero measurand output and low thermal zero drift. The light weight flat case is designed for adhesive mounting.

2.0 **PERFORMANCE**

All specifications assume +75°F (+24°C) and 10 volts excitation.

			-6K	-20K	-60K
2.1	RANGE	(g)	6,000	20,000	60,000
2.2	OVERANGE LIMIT [1]	(g)	18,000	60,000	180,000
2.3	AMPLITUDE LINEARITY [1]		±2% of reading up to acceleration corresponding to the recommended range. Measurement uncertainties prevent stating this as a specification limit at accelerations above 10,000 g.		
2.4	ZERO SHIFT DUE TO SHOCK		0.5 mV maximum for half-sine acceleration pulse at 200 mV output, duration greater than 20 microseconds or five periods of the natural frequency.		
2.5	MOUNTED FREQUENCY RESPONSE [2] ±5% Deviation at		20 kHz	50 kHz	100 kHz
2.6	SENSITIVITY (Microvolts/g)				
	Min		15	5	1.5
	Typ		30	10	5
	Max		50	15	8.5
2.7	RESONANT FREQUENCY (Kilohertz)				
	Min		120	220	400
	Typ		180	350	700
2.8	TRANSVERSE SENSITIVITY [3]		3% maximum. See Figure 1 for direction of minimum transverse sensitivity		

E

2.9	THERMAL SENSITIVITY SHIFT	Typical deviation is -1.2% change in sensitivity per +18°F (+10°C) change in case temperature.
2.10	ZERO MEASURAND OUTPUT	±100 mV maximum at +75°F (+24°C)
2.11	THERMAL ZERO SHIFT	±50 mV maximum, relative to +75°F (+24°C), over operating temperature
3.0	**ELECTRICAL**	
3.1	EXCITATION	10.00 Vdc, 12 Vdc maximum
3.2	RESISTANCE	650± 300 ohms 650± 300 ohms 1200 ± 400 ohms
3.3	THERMAL COEFFICIENT OF RESISTANCE	1550 ppm/deg C (1.55% change in resistance per 18°F [10°C] change in case temperature.
3.4	WARM-UP TIME	1 second maximum to meet all specifications. Depending on thermal conductivity of mounting surface, the surface temperature may change over a period of minutes causing a drift in ZMO. See note [3].
4.0	**PHYSICAL**	
4.1	CASE MATERIAL	Alumina substrate with liquid crystal polymer cover.
4.2	WEIGHT	0.06 grams
4.3	IDENTIFICATION	Model number and serial number on top of unit.
4.4	MOUNTING [3]	Structural epoxy under the substrate is recommended to supplement the strength of the electrical connection.
4.5	ELECTRICAL CONNECTIONS	Wrap-around pads and castellations for conductive epoxy or solder [4].
5.0	**ENVIRONMENTAL**	
5.1	TEMPERATURE	
5.1.1	Operating	-65°F to +250°F (-54°C to +121°C)
5.1.2	Non-operating	TBD [4]
5.2	SHOCK LIMITS [1] [3] (in any direction)	Half-sine pulse of three times the recommended range. Pulse duration should be the greater of 20 microseconds or five periods of the resonant frequency.

5.3	HUMIDITY	Epoxy sealed
5.4	BASE STRAIN SENSITIVITY	0.5 mV maximum at 250 microstrain per ISA-RP37.2-1982
6.0	**CALIBRATION DATA SUPPLIED**	Measured with 10.00 Vdc excitation at room temperature
6.1	SENSITIVITY	Microvolts/g, using shock level of 2000 g minimum
6.2	ZERO MEASURAND OUTPUT	Millivolts
6.3	IINPUT AND OUTPUT IMPEDANCE	Ohms

NOTES:

[1] The unit will operate at accelerations above its recommended range, up to the overrange limit (possibly with slightly degraded linearity). However, above this higher limit, sensor failure may occur. The recommended range is given more to conservatively establish a safety margin than to specify a limit of performance characteristics.

IMPORTANT: Frequency content of shocks which exceed the overrange limits of the Model 70 often contain significant amplitudes well above 100 kHz. Signal conditioning with insufficient bandwidth may attenuate the signal and indicate significantly lower peak accelerations than actually occur.

[2] Frequency response should deviate by less than ±5% from dc to indicated frequency, based on the predicted response of a 'single degree of freedom' system. Acceleration levels of conventional techniques are too low for accurate analysis of the frequency response of the higher range models. Measurement uncertainties above 10 kHz prevents stating ±5% as a specification limit.

These estimates apply to the transducer mounted to an infinitely stiff surface. Frequency response deviations at lower frequencies are likely due to resonances of unsupported thin circuit boards.

NOTE: The sensor chip includes two masses, each with a separate resonance frequency. Both resonances satisfy the specified minimum resonance frequency. If these resonances are excited, the envelope of the transducer output will exhibit a "beat" frequency, which will not adversely affect results if the signal conditioning is linear at these frequencies.

[3] For best performance, the accelerometer should be attached parallel to a clean, flat surface. The adhesive should be chosen to match the strength and temperature requirements of the measurement environment. For best frequency response, keep the adhesive under the accelerometer as thin as possible. Tilt of the transducer relative to the mounting surface will affect output due to transverse sensitivity. Thermal conductivity of the adhesive and mounting surface may affect warm up characteristics.

[4] Solder using temperature controlled tip at 500°F (260°C) for 10 seconds maximum. Recommended solder is Sn63.

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PS70	
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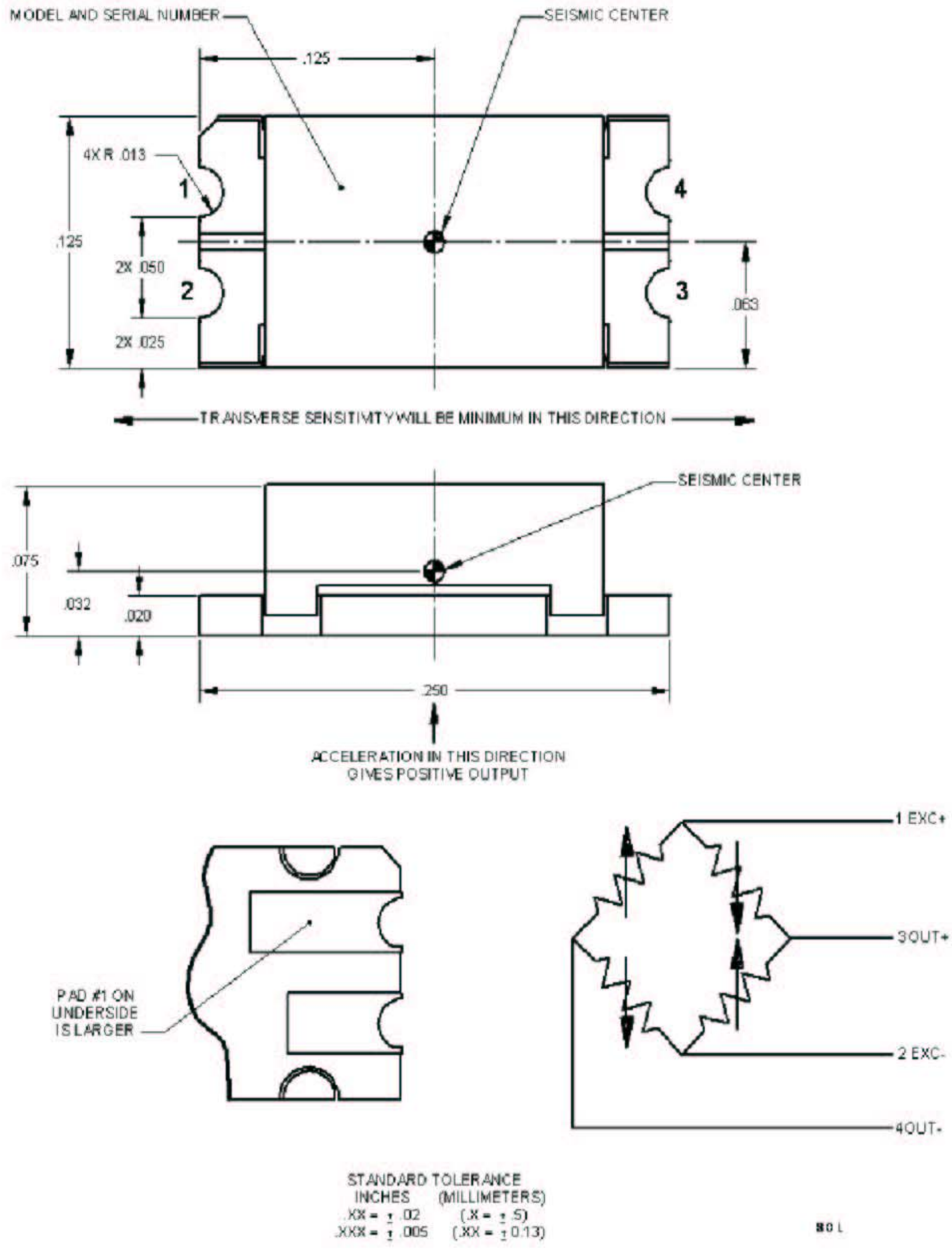

FIGURE 1 – OUTLINE DRAWING

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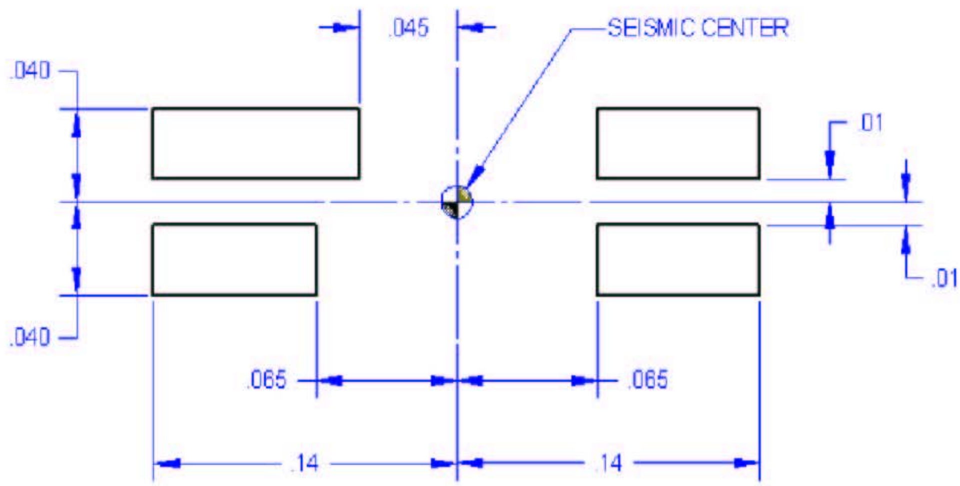

RECOMMENDED FOOTPRINT

STANDARD TOLERANCE
INCHES (MILLIMETERS)
.XX = ± .02 (.X = ± .5)
.XXX = ± .005 (.XX = ± 0.13)

SOL

FIGURE 2 - OUTLINE DRAWING

Appendix B. Model 73 Gage Specifications

This appendix appears in its original form, without editorial change.

OUT ON EO
26286 (CDS)

ORIGINATED	PC	10-17-03	PERFORMANCE SPECIFICATION TRIAXIAL ACCELEROMETER (FOR MODEL 73-XXX-YYY-ZZZ)	PS73	
CHECKED	JRL	10-17-03		PAGE	1 OF 5
APPROVED	KAP	10-17-03		REVISION	A
				EO NUMBER	26114
				DATE	10-16-03

1.0 **DESCRIPTION**

The ENDEVCO® Model 73-XXX-YYY-ZZZ is an assembly of three miniature, rugged, undamped, piezoresistive accelerometers designed for shock measurements in three directions. The Leadless Chip Carrier package is designed for surface mount attachment to circuit boards. The highly efficient sensing system of the Model 73 is sculpted from single crystal silicon, which includes the inertial masses and strain gages arranged in a four-active-arm Wheatstone bridge circuit (patent numbers 4,498,229, 4,605,919 and 4,689,600) for each axis. The extremely small size and unique construction of the elements allows exceptionally high resonant frequencies. On-chip balance resistors provide low zero measurand output and low thermal zero drift. The light flat case is designed for adhesive mounting.

2.0 **PERFORMANCE**

All specifications assume +75°F (+24°C) and 10 volts excitation.

			-6K	-60K
2.1	RANGE	(g)	6,000	60,000
2.2	OVERANGE LIMIT [1]	(g)	18,000	180,000
2.3	AMPLITUDE LINEARITY [1]		±2% of reading up to acceleration corresponding to the recommended range. Measurement uncertainties prevent stating this as a specification limit at accelerations above 10,000 g.	
2.4	ZERO SHIFT DUE TO SHOCK		0.5 mV maximum for half-sine acceleration pulse at 200 mV output, duration greater than 20 microseconds or five periods of the natural frequency.	
2.5	MOUNTED FREQUENCY RESPONSE [2] ±5% Deviation at		20 kHz	100 kHz
2.6	SENSITIVITY (Microvolts/g)			
	Min		15	1.5
	Typ		30	5
	Max		50	8.5
2.7	RESONANT FREQUENCY (Kilohertz)			
	Min		120	400
	Typ		180	700
2.8	TRANSVERSE SENSITIVITY [3]		3% maximum. See Figure 1 for direction of minimum transverse sensitivity	

2.9	THERMAL SENSITIVITY SHIFT	Typical deviation is -1.2% change in sensitivity per +18°F (+10°C) change in case temperature.
2.10	ZERO MEASURAND OUTPUT	±100 mV maximum at +75°F (+24°C)
2.11	THERMAL ZERO SHIFT	±50 mV maximum, relative to +75°F (+24°C), over operating temperature
3.0	**ELECTRICAL**	
3.1	EXCITATION	10.00 Vdc, 12 Vdc maximum
		-6K / -60K
3.2	RESISTANCE	650 ± 300 ohms / 1200 ± 400 ohms
3.3	THERMAL COEFFICIENT OF RESISTANCE	1550 ppm/deg C (1.55% change in resistance per 18°F [10°C] change in case temperature.
3.4	WARM-UP TIME [3]	1 second maximum to meet all specifications. Depending on thermal conductivity of mounting surface, the surface temperature may change over a period of minutes causing a drift in ZMO.
4.0	**PHYSICAL**	
4.1	CASE MATERIAL	Alumina substrate with liquid crystal polymer covers.
4.2	WEIGHT	0.92 grams
4.3	IDENTIFICATION	Model number and serial number on top of unit.
4.4	MOUNTING [3]	Structural epoxy under the substrate is recommended to supplement the strength of the electrical connection.
4.5	ELECTRICAL CONNECTIONS	Wrap-around pads and castellations for conductive epoxy or solder [4].
5.0	**ENVIRONMENTAL**	
5.1	TEMPERATURE Operating Non-operating	 -65°F to +250°F (-54°C to +121°C) -65°F to +356°F (-54°C to +180°C) [4]
5.2	SHOCK LIMITS [1] [3] (in any direction)	Half-sine pulse of three times the recommended range. Pulse duration should be the greater of 20 microseconds or five periods of the resonant frequency.

5.3	HUMIDITY	Epoxy sealed
5.4	BASE STRAIN SENSITIVITY	0.5 mV maximum at 250 microstrain per ISA-RP37.2-1982
6.0	**CALIBRATION DATA SUPPLIED**	Measured with 10.00 Vdc excitation at room temperature
6.1	SENSITIVITY	Microvolts/g, using shock level of 2000 g minimum
6.2	ZERO MEASURAND OUTPUT	Millivolts
6.3	IINPUT AND OUTPUT IMPEDANCE	Ohms

NOTES:

[1] The unit will operate at accelerations above its recommended range, up to the overrange limit (possibly with slightly degraded linearity). However, above this higher limit, sensor failure may occur. The recommended range is given more to conservatively establish a safety margin than to specify a limit of performance characteristics.

IMPORTANT: Frequency content of shocks that exceed the overrange limits of the Model 73 often contains significant amplitudes well above 100 kHz. Signal conditioning with insufficient bandwidth may attenuate the signal and indicate significantly lower peak accelerations than actually occur.

[2] Frequency response should deviate by less than ±5% from dc to indicated frequency, based on the predicted response of a 'single degree of freedom' system. Acceleration levels of conventional techniques are too low for accurate analysis of the frequency response of the higher range models. Measurement uncertainties above 10 kHz prevents stating ±5% as a specification limit.

These estimates apply to the transducer mounted to an infinitely stiff surface. Frequency response deviations at lower frequencies are likely due to resonances of unsupported thin circuit boards.

NOTE: The sensor chips each include two masses, each with a separate resonance frequency. Both resonances satisfy the specified minimum resonance frequency. If these resonances are excited, the envelope of the transducer output will exhibit a "beat" frequency, which will not adversely affect results if the signal conditioning is linear at these frequencies.

[3] For best performance, the accelerometer should be attached parallel to a clean, flat surface. The adhesive should be chosen to match the strength and temperature requirements of the measurement environment. For best frequency response, keep the adhesive under the accelerometer as thin as possible. Tilt of the transducer relative to the mounting surface will affect output due to transverse sensitivity. Thermal conductivity of the adhesive and mounting surface may affect warm up characteristics.

[4] Solder using temperature controlled tip at 500°F (260°C) for 10 seconds maximum. Recommended solder is Sn63.

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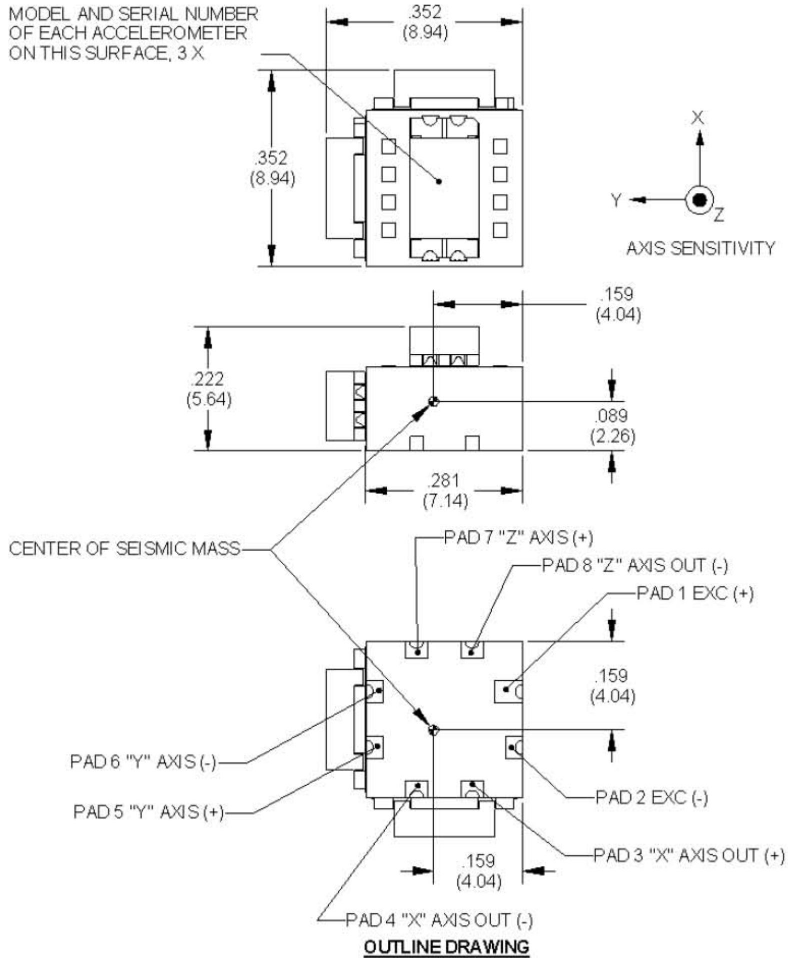

STANDARD TOLERANCE
INCHES (MILLIMETERS)
.XX = ± .02 (.X = ± .5)
.XXX = ± .005 (.XX = ± .13)

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FIGURE 1 – OUTLINE DRAWING

ED279-2 Rev B	03-29-2000

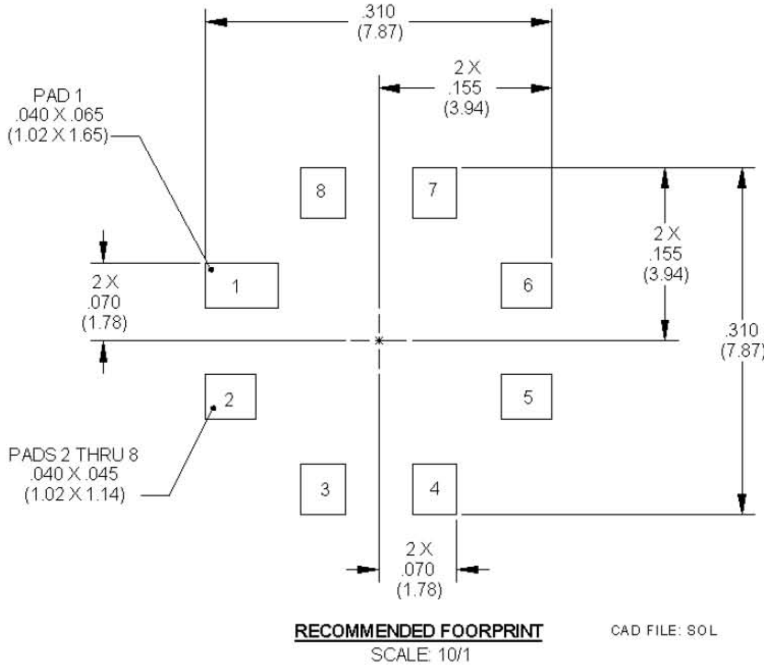

FIGURE 2 - OUTLINE DRAWING

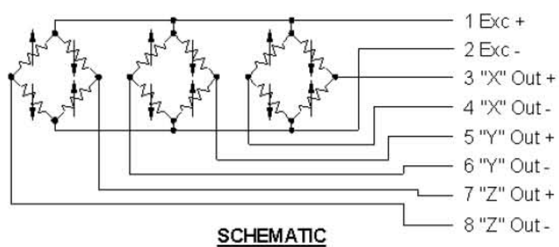

FIGURE 3 - SCHEMATIC

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